/ ***Marley Class F600*** *Cooling Tower* /

User Manual 08-12A

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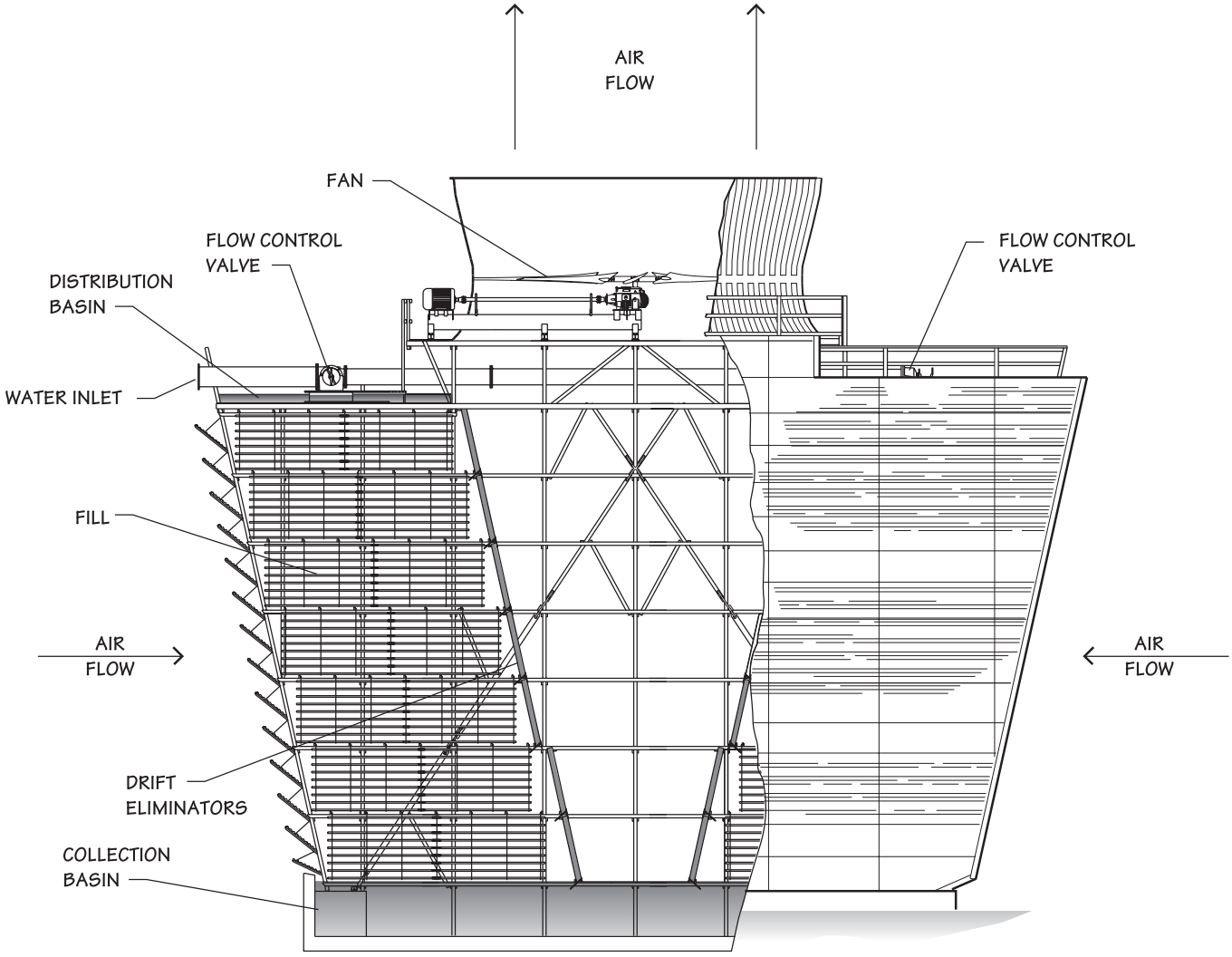
Tower Schematic



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The following defined terms are used throughout this manual to bring attention to the presence of hazards of various risk levels, or to important information concerning the life of the product.

⚠ Warning

Indicates presence of a hazard which can cause severe personal injury, death or substantial property damage if ignored.

⚠ Caution

Indicates presence of a hazard which will or can cause personal injury or property damage if ignored.

Note

Indicates special instructions on installation, operation or maintenance which are important but not related to personal injury hazards.

General

A cooling tower, like any heat exchanger, exchanges all heat imposed upon it from one fluid to another fluid. For a cooling tower, heat from the water is put into the air. The plant process replenishes the heat to the water, typically at another heat exchanger such as a condenser. A cooling tower differs from many heat exchangers in that heat is transferred in two forms – sensible and latent heat. As heat is transferred from the water, the air temperature increases (sensible) and the air's water content, or humidity, also increases (latent). As the heat load, inlet air wet-bulb temperature, or airflow on a cooling tower changes, the cooling tower will respond by finding a new equilibrium with the process. The cooling tower will still dissipate all the heat from the process, but at new water temperatures.

The cooling tower cold water temperature is the supply water temperature to the condenser, and changes in the cold water temperature usually affect efficiency of the plant output. Although the reduced cold water temperatures that result from maximum fan power utilization are usually beneficial to plant output, the amount of fan power affects the cost of running the cooling tower. As these variables interact on a cooling tower, the operator must find the proper trade-off between these opposing forces.

These instructions will assist in obtaining efficient, long life from Marley cooling equipment. Direct questions concerning tower operation and maintenance to your Marley sales representative. Always include your tower serial number when writing for information or ordering parts. Look for this number on the nameplate on the tower endwall access door.

Before Start-up

⚠ Caution

SAFETY–Temporary safety barricades should be placed around any exposed openings in the operating (or non-operating) tower, safety harnesses should be worn by personnel where appropriate, and other safety precautions should be taken in compliance with OSHA or other appropriate regulations and standards.

CLEANING–Remove any dirt and trash which has accumulated in the hot water distribution basins. Clean any nozzles that are clogged. Remove any sediment from the cold water basin, sump and screens. Use a water hose to flush cold water basins. **If you are restarting or recommissioning a previously used tower, see Warning note on page 12.**

OPERATE WATER SYSTEM–Complete steps 1 thru 4 under **Initial Starting Procedure** below. Circulate water over the tower continuously for several days before starting the mechanical equipment and putting the tower into continuous operation.

Note

Do not circulate water over the tower in freezing weather without a heat load. (See caution, page 6.)

Initial Starting Procedure

1–Fill the cold water basin and circulating water system to a level 1/2" (13 mm) below the overflow.

2–Completely open all hot water flow control valves.

3–Prime and start the circulating water pumps one at a time. Increase the flow of circulating water gradually to design water rate to avoid surges or water hammer which could damage the distribution piping.

4–When flow has stabilized at or near the design rate, adjust water makeup to maintain the level that the water has pumped down to in the cold water basin. See **Cold Water Collecting Basin** on page 8. This should coincide reasonably with the recommended operating water level indicated on the Marley project drawings.

5–Adjust flow control valves to equalize the hot water depth in the distribution basins. Adjust deepest water level basins first. Lock valves in desired position with valve locking bar.

6–Start the fan. After 30 minutes operating time to permit Geareducer oil to come up to operating temperature, check motor load with watt meter, or take operating volt and ampere readings and calculate motor hp. Refer to Marley **Fan User Manual** for instructions.

⚠ Caution

If it is necessary to pitch fans to pull correct contract horsepower, measure results when circulating design water rate at design hot water temperature. Horsepower will change with air density. Lock out all electrical service before entering fan area.

Routine Starting Procedure

After periods of routine shutdown, the following restarting procedure should be followed:

1–Start the circulating water pump(s). Increase the flow of circulating water gradually to design water rate to avoid surges or water hammer which could damage the distribution piping.

⚠ Caution

Circulating cold water over a tower in freezing weather will cause ice to form – which may cause damage to the fill system. Water should be bypassed until the heat load causes its temperature to rise above 70°F (21°C), at which time it may be directed over the tower. Also, towers must not be operated with reduced water rate and/or no heat load during freezing weather. IF A BYPASS IS USED, DO NOT MODULATE. Bypass design must be reviewed by SPX.

2–Start the fan(s). On multicell towers, only as many fans should be started as are needed to produce the desired cold water temperature. If the tower is equipped with two-speed motors, fans may be progressively started at half speed, increasing to full speed as necessary to maintain the desired cold water temperature. See **Temperature Control and Energy Management**, pages 9 and 10.

Operation

TOWER PERFORMANCE–Keep the tower clean and the water distribution uniform to obtain continued maximum cooling capacity. (See **Warning** note, page 12.) Do not allow excessive deposits of scale or algae to build up on the fill or eliminators. Keep the metering orifices free of debris to assure correct distribution and cooling of water.

The capacity of a tower to cool water to a given cold water temperature varies with the wet-bulb temperature and the heat load on the tower. As the wet-bulb temperature drops, the cold water temperature also drops. However, the cold water temperature does not drop as much as the wet-bulb temperature. Wet-bulb temperature is the temperature indicated by the wet-bulb thermometer of a psychrometer.

A tower does not control the heat load. For a given heat load, the quantity of water circulated determines the cooling range. The hot and cold water temperatures increase with higher heat loads. Cooling range is the temperature

difference between the hot water coming into the cooling tower and the cold water leaving the tower.

FAN DRIVE–Air is caused to move through the tower by the operation of electric motor-driven fans. At full speed, these fans are designed (and pitched) to move the amount of air required to accomplish the design thermal performance. Proper utilization of these fans provides the operator a means by which to adjust the level of thermal performance to suit the requirements of the load. (See **Temperature Control and Energy Management**, pages 9 and 10.)

⚠ Caution

If two-speed motors are used, allow a time delay of a minimum of 20 seconds after de-energizing the high speed winding and before energizing the low speed winding. Tremendous stresses are placed on driven machinery and motor unless the motor is allowed to slow to low speed rpm or less before the low speed winding is energized. When changing the direction of fan rotation, allow a minimum of two minutes time delay before energizing the fan motor.

HOT WATER DISTRIBUTION SYSTEM–Hot water from the process flows into open distribution basins situated above the banks of fill in each cell. Metering orifices in the floor of these basins distribute water evenly over the fill.

⚠ Caution

If an Amertap condenser tube cleaning system is part of plant equipment, care should be taken during operation to back-wash the strainer section only after the sponge rubber cleaning balls are removed from the system by trapping them in the collector. If the balls are allowed to enter the cooling tower supply piping, they can clog the plastic metering orifices. Clogged orifices will cause unequal water distribution over the fill which will affect thermal performance. Extensive clogging can lead to overflowing of the distribution basins and possible ice damage to towers installed in freezing climates. The basins should be frequently checked for orifice clogging until such time as the operational sequence of the Amertap system assures that no balls enter the cooling tower piping.

FILL–Water leaving the distribution basin orifices is distributed uniformly over the fill plan area. The water cascades downward through the fill, maximizing water surface exposure to the air being moved by the fans.

DRIFT ELIMINATORS–Air leaving the fill passes through a bank of drift eliminators blanketing the entire height of the fill. The purpose of these drift eliminators is to minimize the amount of water that is caused to exit the tower by the velocity of the moving airstream.

COLD WATER COLLECTING BASIN–Water leaving the fill falls into the cold water basin that forms the base of the tower. The normal water depth in a concrete basin is 9 to 15 inches (229 to 381 mm) below the curb. Adjust the make-up water supply to maintain this water level. Maintain sufficient water depth to prevent cavitation.

WINTER OPERATION–During periods of low temperature operation, 35° to 40°F (2°to 4°C) or below, ice will form on the relatively dry parts of the tower that are in contact with the incoming air. Primarily, this includes the louvers and adjacent structural framing.

Ice forming characteristics on any given tower will vary, depending on velocity and direction of wind, circulating water rate and heat load. Excessive ice formation may be controlled by regulating air and water flow through the tower by one or more of the following procedures:

1–Shut the fan down. This reduces the cooling rate to a minimum and increases the quantity of warm water on the louvers to a maximum, Except for extreme cold conditions or extended freezing conditions, this procedure will normally control ice formation. For automatic operation, a timer switch can be provided to shut the fan down for a few minutes each hour.

2–If the tower has two-speed motors, operate the fan at half speed forward. This reduces the cooling rate (heat transfer) and increases the quantity of warm water on the louvers.

3–Under extended extreme cold conditions, it may be necessary to operate the fan in reverse. This forces warm air out through the louvers, melting any accumulated ice. Reversal may be at either full or half speed, however, full speed is recommended if adequate heat load is available. Reverse operation of the fan should only be used to control ice, not prevent it. Reverse fan operation should not exceed 15 to 20 minutes. Usually much less time than this is required to melt accumulated ice. **(See Caution, page 7)**

4–With no heat load on the circulating water, icing cannot be controlled effectively by air control during freezing weather. Towers must not be operated with reduced water rate and/or no heat load during freezing weather. If a bypass directly into the cold water basin is used, all water must be bypassed. Design of a bypass arrangement must include consideration of water impact effect on tower components.

⚠ **Caution**

Reverse operation of fans for prolonged periods during subfreezing weather can cause severe damage to fans and fan cylinders. Ice can accumulate inside fan cylinders at fan blade plane of rotation and fan blade tips will eventually strike this ring of ice, damaging the fan blades or cylinder. Ice can also accumulate on fan blades and be thrown off, damaging fan cylinder or blades. Reverse operation of fans with adjacent fans not operating increases probability of icing. The low discharge velocity of moist air from fan cylinders in which fans are not in operation can result in moisture-laden air being pulled into the adjacent cylinder in which the fan is operating in reverse, increasing this ice buildup. Therefore, fans each side of the one operating in reverse must be operated in forward rotation at full or half speed, or all fans must be operated in reverse. Allow at least a 10 minute delay between reverse operation and forward operation during subfreezing weather to permit ice to dissipate from fan blades and fan cylinders. See Fan Drive Caution note on page 7 for fan speed change and reversing precautions.

Temperature Control and Energy Management

The wet bulb temperature of the ambient air varies significantly on a daily basis, and considerably from season to season. As the wet bulb temperature reduces, the tower becomes capable of producing colder and colder water – or it becomes capable of producing a given cold water temperature at reduced airflow through the tower. These characteristics are the "opposing forces" referred to under **General** on page 4.

MAXIMIZING TOWER PERFORMANCE–If your process is one which benefits from the coldest possible water; that is, if colder water allows you to produce more product – or allows you to operate your system at significantly lower cost, then continuous full speed operation of the fan(s) may be your best mode of operation.

In this mode of operation, concern for the cold water temperature level would be limited to the potential for the tower to form ice during freezing weather. **(See Caution page 6, and WINTER OPERATION pages 8 and 9)** Although the 70°F (21°C) cold water temperature indicated on page 6 is appropriate for cold weather start-up and operation, acceptable temperatures during full operation in spring, summer and fall may be appreciably lower, perhaps as low as 50°F (10°C) or less. **Refer to your performance curves for expected tower cold water temperatures at varying flow rates, ranges, and wet bulb temperatures.**

MINIMIZING TOWER ENERGY USE–Many processes gain no operating or production benefits from water temperatures below a certain level, and for many that level may be only 10°F to 15°F (5° to 8°C) below the design cold water temperature. When a reducing ambient wet bulb permits the tower to reach that target cold water temperature level, further reductions in the wet bulb temperature permit manipulation of fan speeds or operation to maintain that temperature level.

Single speed fans can be cycled on and off for cold water temperature control, with the steps of control depending upon the number of fan cells in the tower. Two speed motors offer twice as many control steps – with the added bonus that half speed (which produces half of the normal airflow through the tower) requires less than 20% of the full speed power requirement. **(If your tower is equipped with Marley Controls, please refer to the appropriate User Manuals.)**

⚠ **Caution**

Excessive fan cycling may shorten the motor's expected service life. On fans 20 feet (6 meter) diameter and smaller allow for 4 to 5 starts per hour. On larger fans, 2 or 3 starts per hour may be the limit. On two speed motors each low speed start and each high speed start count as one start.

Variable frequency drives, of course, provide the ultimate in both temperature control and energy management and can be easily retrofitted to your system. Please discuss this with your Marley representative. **(If your tower is equipped with a Marley VFD drive, please refer to the appropriate User Manual.)**

Unit Maintenance

Well maintained equipment gives the best operating results and the least maintenance cost. A regular inspection schedule is recommended to insure effective, safe operation of the cooling tower. Use the schedule on page 19 to obtain continuously good performance with the least tower maintenance. See Inspection Checklist, pages 22 and 23 in this manual. Keep a continuous lubrication and maintenance record for each cooling tower. Conduct regular inspection and repair of personnel safety items (items 19 and 20 in Table on page 19). Maintaining a record of this is especially important. For a supply of check list forms, contact your Marley sales representative.

HOT WATER DISTRIBUTION BASINS–Metering orifices in the floor of the hot water basins may be cleaned without shutting down any part of the tower. Remove dirt, algae, leaves, etc., which might get in these basins or orifices. The metering orifices must be kept in place to assure proper water distribution.

Completely open and close flow control valves at least semi-annually to remove any scale on the threads. Before operating valve, measure distance from valve stem guide to operating handle to assist in resetting the valve to the original operating position. Grease the stainless steel stem to prevent scale forming. Lubricate the valves at least semiannually with a lithium base NLGI No. 2 consistency grease. More frequent relubrication of valves and valve stems may be dictated by circulating water conditions.

COLD WATER COLLECTING BASIN–Inspect collecting basin occasionally for cracks, leaks, and spalling and repair if necessary. Maintain a positive Langelier index in your circulating water. (See **Water Treatment,** page 15.) Keep cold water outlets clean and free of debris. Makeup and circulating water controls must operate freely and maintain the desired water quantity in the system.

TOWER FRAMEWORK–Keep framework bolts tight. Pay particular attention to bolts in the mechanical equipment supports. Do not crush fiberglass by overtightening.

DRIVE SHAFT–Check drive shaft alignment and condition of couplings every six months. See the **Drive Shaft User Manual** for correcting misalignment, balancing or replacing parts.

ELECTRIC MOTOR–Lubricate and maintain each electric motor in accordance with the manufacturer's instructions. If repair work is necessary, contact the nearest representative of the motor manufacturer. See Warranty Section of Marley **Electric Motors User Manual.**

FAN–Inspect fan blade surfaces every six months. For detailed maintenance information, refer to **Marley Fan User Manual.**

GEAREDUCER–Make weekly and monthly oil checks. Refer to the **Geareducer User Manual** for detailed maintenance instructions.

PAINTING–Periodically clean and, if necessary, recoat any chipped or damaged paint to prevent corrosion.

Cooling Tower Cleaning

⚠ **Warning**

Any evaporative-type cooling tower must be thoroughly cleaned on a regular basis to minimize the growth of bacteria, including Legionella Pneumophilla, to avoid the risk of sickness or death. Service personnel must wear proper personal protective equipment. Do NOT attempt any service unless the fan motor is locked out.

Operators of evaporative cooling equipment, such as water cooling towers, should follow maintenance programs which will reduce to an absolute minimum the opportunity for bacteriological contamination. Public Health Service officials have recommended that "good housekeeping" procedures be followed, such as: regular inspections for concentrations of dirt, scale, and algae; periodic flushing and cleaning; and the following of a complete water treatment program including biocidal treatment.

Visual inspection should take place at least once a week during the operating season. Periodic flushing and cleaning should be done at least twice a year. Nozzles, louvers, drift eliminators, and easily accessible fill surfaces should be flushed by use of a moderate-pressure water nozzle, being careful not to cause physical damage. A reliable water treatment program should be installed and maintained.

Water Treatment

BLOWDOWN–Blowdown, or bleed-off, is the continuous removal of a portion of the water from the circulating system. It is used to prevent dissolved solids from concentrating to the point where they will form scale. The amount of blowdown required depends upon the cooling range (design hot water temperature minus design cold water temperature) and the composition of the makeup water (water added to the system to compensate for losses by blowdown, evaporation and drift). The following table shows the minimum amount of blowdown (percent of flow) required to maintain different concentrations with various cooling ranges:

Cooling Range	Number of Concentrations						
	1.5X	2.0X	2.5X	3.0X	4.0X	5.0X	6.0X
5°F (2.78°C)	.78	.38	.25	.18	.11	.08	.06
10°F (5.56°C)	1.58	.78	.51	.38	.25	.18	.14
15°F (8.33°C)	2.38	1.18	.78	.58	.38	.28	.22
20°F (11.11°C)	3.18	1.58	1.05	.78	.51	.38	.30
25°F (13.89°C)	3.98	1.98	1.32	.98	.64	.48	.38

Multipliers are based on drift of 0.02% of the circulating water rate.

EXAMPLE: 7000 GPM (1590 m^3/hr) circulating rate, 18°F (10°C) cooling range. To maintain 4 concentrations, the required blowdown is 0.458% or .00458 times 7000 GPM (1590 m^3/hr) which is 32.1 GPM (7 m^3/hr).

If tower is operated at 4 concentrations, circulating water will contain four times as much dissolved solid as the makeup water, assuming none of the solids form scale or are otherwise removed from the system.

Note

The use of corrosion and scale inhibitors is strongly recommended.

CHEMICAL TREATMENT–In some cases chemical treatment of the circulating water is not required if adequate blowdown is maintained. In most cases, however, chemical treatment is required to prevent scale formation and corrosion. Sulfuric acid or one of the polyphosphates is most generally used to control calcium carbonate scale. Various proprietary materials containing phosphates or other compounds are available for corrosion control. When water treatment chemicals are required, the services of reliable water treating companies should be obtained.

Note

Preferred Cooling Tower Water Condition Limits For Standard Construction Materials		
	pH	- 6.5 to 9.0
	Maximum Water Temperature	- 120°F (48.9°C)
	Langelier Saturation Index	- 0.0 to 1.0
	M-Alkalinity	- 100 to 500 ppm as $CaCO_3$
	Silica	- 150 ppm as SiO_2
	Iron	- 3 ppm
	Manganese	- 0.1 ppm
	Oil and Grease	- 10 ppm for splash-filled towers. None allowed for film-filled towers.
	Sulfides	- 1 ppm
	Ammonia	- 50 ppm if copper alloys are presents.
	Chlorine	- 1 ppm free residual intermittently (shock), or 0.4 ppm continuously.
	Organic Solvents	- None allowed.
	Total Dissolved Solids	- Over 5000 ppm can affect thermal performance.
Cations:	Calcium	- 800 ppm as $CaCO_3$
	Magnesium	- Depends of pH and Silica level.
	Sodium	- No limit.
Anions:	Chlorides	- 750 ppm as NaCl, 455 ppm as Cl^-
	Sulfates	- 800 ppm as $CaCO_3$
	Nitrates	- 300 ppm (nutrient for bacteria)
Suspended Solids:	Splash-Type Fill	- No specific limit.

Unless unusual water conditions have been anticipated and compensated for by the use of premium materials in the construction of the tower, then it is the owner/operator's responsibility to maintain water conditions within the limits tabled on page 14 by the appropriate use of blowdown, chemical treatment, filtration, cleaning, etc.

Slime, a gelatinous bacteria growth, and algae, a green or brown plant growth, may grow in the cooling tower or heat exchangers. Their presence can interfere with cooling efficiencies. Proprietary compounds are available from water treating companies for the control of slime and/or algae; however, compounds which contain copper are not recommended.

The Langelier index (calcium carbonate saturation index) has proven to be an effective tool in predicting the aggressiveness of cooling tower water toward concrete. The Langelier index relates the methyl orange alkalinity; the calcium hardness; the total solids; the pH value; and the temperature of the water. From these values it is possible to calculate the index and predict the corrosive tendencies of the tower water toward concrete. Maintaining a slightly positive Langelier index (0.0 – 1.0) provides excellent protection of concrete.

Data For Rapid Calculation of Saturation Index
Saturation Index = pH(actual) - (9.3 + A + B) + (C + D)

A		B		C		D	
Total Solids ppm	Value to Apply	Water Temp. (°F)	Value to Apply	Calcium Hardness ppm	Value to Apply	M.O. Alkalinity ppm	Value to Apply
50 - 300	0.1	32 - 34	2.6	10 - 11	0.6	10 - 11	1.0
400 - 1000	0.2	36 - 42	2.5	12 - 13	0.7	12 - 13	1.1
		44 - 48	2.4	14 - 17	0.8	14 - 17	1.2
		50 - 56	2.3	18 - 22	0.9	18 - 22	1.3
		58 - 62	2.2	23 - 27	1.0	23 - 27	1.4
		64 - 70	2.1	28 - 34	1.1	28 - 34	1.5
		72 - 80	2.0	35 - 43	1.2	35 - 43	1.6
		82 - 88	1.9	44 - 55	1.3	44 - 55	1.7
		90 - 98	1.8	56 - 69	1.4	56 - 69	1.8
		100 - 110	1.7	70 - 87	1.5	70 - 87	1.9
		112 - 122	1.6	88 - 110	1.6	88 - 110	2.0
		124 - 132	1.5	111 - 138	1.7	111 - 138	2.1
		134 - 146	1.4	139 - 174	1.8	139 - 174	2.2
		148 - 160	1.3	175 - 220	1.9	175 - 220	2.3
		162 - 178	1.2	230 - 270	2.0	230 - 270	2.4
				280 - 340	2.1	280 - 340	2.5
				350 - 430	2.2	350 - 430	2.6
				440 - 550	2.3	440 - 550	2.7
				560 - 690	2.4	560 - 690	2.8
				700 - 870	2.5	700 - 870	2.9
				880 - 1000	2.6	880 - 1000	3.0

Based on Langelier formulas, Larson-Buswell residue, temperature adjustments and arranged by Eskel Nordell.

FOAMING–Heavy foaming sometimes occurs when a new tower is put into operation. This type of foaming generally subsides after a relatively short period of operation. Persistent foaming can be caused by the concentrations of certain combinations of dissolved solids or by contamination of the circulating water with foam-causing compounds. This type of foaming can sometimes be minimized by increasing the blowdown, but in some cases foam depressant chemicals must be added to the system. Foam depressants are available from a number of chemical companies.

Seasonal Shutdown Instructions

TOWER–Drain all tower piping.

During shutdown, clean the tower and make any necessary repairs. Apply protective coating as required to all metal parts. Particular attention should be given to mechanical equipment supports, drive shaft and drive shaft guards. Visually inspect for concrete deterioration.

⚠ **Warning**

See Warning note on page 12 regarding tower cleaning.

MECHANICAL EQUIPMENT

Shutdown for less than 3 months.

Each month, drain water condensate from the lowest point of the Geareducer and its oil system. Check oil level and add oil if necessary. Operate Geareducer to recoat all interior surfaces with oil. Before start-up, drain water condensate and check oil level. Add oil if necessary.

Refer to **Geareducer User Manual** for maintenance and lubrication instructions.

Shutdown for 3 months or longer.

If the motors have space heaters, operate mechanical equipment one hour each month. Space heaters should be energized anytime motor is not operating. If the motors do not have space heaters, operate mechanical equipment one hour each week. At start-up, operate mechanical equipment one hour or until oil is warm, then shut the equipment down. Drain the oil and refill with new oil. Refer to **Geareducer User Manual** for instruction on changing oil. Refer to Marley **Downtime Instruction Manual** for downtime of 6 months or longer.

Electric Motors

⚠ **Caution**

Do not start motor without determining that there will be no interference with free rotation of the fan drive. Refer to Marley Electric Motor User Manual.

If shutdown period is longer than seasonal, contact your Marley sales representative for additional information.

Spare Parts

SPX manufactures and maintains a stock of common replacement parts for all cooling tower mechanical equipment. Shipment of these parts are normally made within ten days after an order is received. If emergency service is necessary, contact the local Marley sales representative for assistance.

To prevent prolonged shutdown periods in case of damage to the mechanical equipment, it is suggested that the following parts be carried in the owner's stock:

- One fan assembly.
- One Geareducer assembly.
- One drive shaft assembly.
- One motor.

Be sure to furnish the tower serial number when ordering parts.

Accessories

Marley accessories are designed for improved maintenance access, safety, component handling, and the general customizing of the tower to suit your process. These accessories include stairways, walkways (external and internal), mechanical equipment removal systems, derricks, davits, hot water basin covers (for algae suppression), motor control centers as well as variable frequency drives (page 10), and other retrofittable control devices.

Please discuss your needs with your Marley sales representative.

Inspection and Maintenance Schedule

General Recommendations

More frequent inspection and maintenance may be desirable

	Fan	Motor	Drive Shaft and Guards	Geareducer	Drift Eliminators	Fill	Cold Water Basin	Hot Water Basin	Float Valve	Suction Screen	Control Valves	Structural Members	Casing and Louvers	Fan Cylinder	Stairs, Ladders, Walkway, Doors, Handrails	Davits, Derricks, Hoists
1. Inspect for clogging					M	M		W		W						
2. Check for unusual noise or vibration	D	D	D	D												
3. Inspect keys, keyways and set screws	S	S	S	S												
4. Make sure vents are open				S												
5. Lubricate (grease)		R									S					
6. Check oil seals				M												
7. Check operating oil level				D												
8. Check static oil level				M												
9. Check oil for water and sludge				M												
10. Change oil				S												
11. Check fan blade tip clearance	S															
12. Check water level							D	D								
13. Check for leakage				W			S	S	S							
14. Inspect general condition	S	S	S	S	Y	S	Y	S	Y	S	S	S	Y	S	S	S
15. Tighten loose bolts	S	S	S	S								Y	R	S		
16. Clean	R	R	R	R	R	R	S	R	R	R	R					
17. Repaint	R	R	R	R												
18. Rebalance	R		R													
19. Completely open and close											S					
20. Inspect/repair for safe use	Y		Y												S	
21. Inspect and repair before each use																R

D – daily; W – weekly; M – monthly; Q – quarterly; S – semi-annually; Y – yearly; R – as required

Troubleshooting

Trouble	Cause	Remedy
Motor Will Not Start	Power not available at motor terminals	• Check power at starter. Correct any bad connections between the control apparatus and the motor.
		• Check starter contacts and control circuit. Reset overloads, close contacts, reset tripped switches or replace failed control switches.
		• If power is not on all leads at starter, make sure overload and short circuit devices are in proper condition.
	Wrong connections	Check motor and control connections against wiring diagrams.
	Low voltage	Check nameplate voltage against power supply. Check voltage at motor terminals.
	Open circuit in motor winding	Check stator windings for open circuits.
	Motor or fan drive stuck	Disconnect motor from load and check motor and Geareducer for cause of problem.
	Rotor defectve	Look for broken bars or rings.
Unusual Motor Noise	Motor running single-phase	Stop motor and attempt to start it. Motor will not start if single-phased. Check wiring, controls, and motor.
	Motor leads connected incorrectly	Check motor connections against wiring diagram on motor.
	Ball bearings	Check lubrication. Replace bad bearings.
	Electrical unbalance	Check voltages and currents of all three lines. Correct if required.
	Air gap not uniform	Check and correct bracket fits or bearing.
	Rotor unbalance	Rebalance.
	Cooling fan hitting guard	Reinstall or replace fan.
Motor Runs Hot	Wrong voltage or unbalanced voltage	Check voltage and current of all three lines against nameplate values.
	Overload	Check fan blade pitch. See Fan User Manual. Check for drag in fan drive train as from damaged bearings.
	Wrong motor RPM	Check nameplate against power supply. Check RPM of motor and gear ratio.
	Bearings overgreased	Remove grease reliefs. Run motor up to speed to purge excessive grease.
	Rotor rubs stator bore	If not poor machining, replace worn bearing.
	Wrong lubricant in bearings	Change to proper lubricant. See motor manufacturer's instructions.
	One phase open	Stop motor and attempt to start it. Motor will not start if single-phased. Check wiring, controls, and motor.
	Poor ventilation	Clean motor and check ventilation openings. Allow ample ventilation around motor.
	Winding fault	Check with Ohmmeter.
	Bent motor shaft	Straighten or replace shaft.
	Insufficient grease	Remove plugs and regrease bearings.
	Deterioration of grease, or foreign material in grease	Flush bearings and relubricate.
	Bearings damaged	Replace bearings.
Motor Does Not Come Up To Speed	Incorrect fan blade pitch	See Fan User Manual for blade pitching instructions.
	Voltage too low at motor terminals because of line drop	Check transformer and setting of taps. Use higher voltage on transformer terminals or reduce loads. Increase wire size or reduce inertia.
	Broken Rotor bars	Look for cracks near the rings. A new rotor may be required. Have motor service person check motor.

Troubleshooting

Trouble	*Cause*	*Remedy*
Wrong Rotation (Motor)	Wrong sequence of phases	Switch any two of the three motor leads.
Geareducer Noise	Geareducer bearings	If new, see if noise disappears after one week of operation. Drain, flush, and refill Geareducer. See Geareducer Service Manual. If still noisy, replace.
	Gears	Correct tooth engagement. Replace badly worn gears. Replace gears with imperfect tooth spacing or form.
Unusual Fan Drive Vibration	Loose bolts and cap screws	Tighten all bolts and cap screws on all mechanical equipment and supports.
	Unbalanced drive shaft or worn couplings	Make sure motor and Geareducer shafts are in proper alignment and "match marks" properly matched. Repair or replace worn couplings. Rebalance drive shaft by adding or removing weights from balancing cap screws. See Drive Shaft Service Manual.
	Fan	Make certain all blades are as far from center of fan as safety devices permit. All blades must be pitched the same. See Fan Service Manual. Clean off deposit build-up on blades.
	Worn Geareducer bearings	Check fan and pinion shaft endplay. Replace bearings as necessary.
	Unbalanced motor	Disconnect load and operate motor. If motor still vibrates, rebalance rotor.
	Bent Geareducer shaft	Check fan and pinion shaft with dial indicator. Replace if necessary.
Fan Noise	Loose fan hub cover	Tighten hub cover fasteners.
	Blade rubbing inside of fan cylinder	Adjust cylinder to provide blade tip clearance.
	Loose bolts in blade clamps	Check and tighten if necessary.

Safety

The tower has been designed to provide a safe working environment while either operating or shut down. The ultimate responsibility for safety rests with the Operator and Owner. When flow to the tower is shut off or when portions of the tower require maintenance, temporary safety barricades may be required around openings. Other safety precautions such as safety harnesses should be utilized where appropriate for compliance with OSHA regulations and standards and good safety practices. **See Warning, page 12.**

Routine periodic maintenance must be performed on all personnel access and material handling accessories in accordance with the following schedule:

	Ladders, Stairways, Walkways, Handrails, Covers, Decks, and Access Doors	Davits, Derricks, and Hoists
Inspect for General Condition	Semi-annually	Semi-annually
Repair for Safe Use	As Required	As Required

Inspection Checklist

Date Inspected _____ Inspected By _____

Owner _____ Location _____

Owner's Tower Designation _____

Tower Manufacturer _____ Model No. _____ Serial No. _____

Process Served by Tower _____ Operation: Continuous Intermittent Seasonal

Design Conditions GPM _____ HW _____ °F CW _____ °F WB _____ °F

Number of Fan Cells _____

Condition: 1—Good 2—Keep an eye on it 3—Needs immediate attention

	1	2	3	Comments
Structure				
Casing Material				
Structural Material				
Fan Deck Material				
Stairway? _____ Material _____				
Ladder? _____ Material _____				
Handrails? _____ Material _____				
Interior Walkway? _____ Material _____				
Cold Water Basin Material _____				
Water Distribution System				
Distribution Basin Material _____				
Inlet Pipe Material _____				
Inlet Manifold Material _____				
Flow Control Valves? _____ Size _____"				
Nozzles – Orifice Diameter _____"				
Heat Transfer System				
Fill _____				
Drift Eliminators _____				
Louvers _____				

Use this space to list specific items needing attention: _____

Inspection Checklist

Condition: 1—Good 2—Keep an eye on it 3—Needs immediate attention

Mechanical Equipment	1	2	3	**Comments**
Gear Drive Units				
Manufacturer _____ Model _____ Ratio _____				
Oil Level: Full Add Immediately Low, check again soon				
Oil Condition: Good Contains Water Contains Metal Contains Sludge				
Oil Used – Type _____				
Seals _____				
Backlash _____				
Fan Shaft Endplay _____				
Any Unusual Noises? No Yes Action Required: _____				
Drive Shafts				
Manufacturer _____ Material _____				
Fans				
Manufacturer _____ Fixed Pitch Adjustable Pitch				
Diameter _____ Number of Blades _____				
Blade Material _____				
Hub Material _____				
Hub Cover Material _____				
Blade Assembly Hardware _____				
Tip Clearance _____"min. _____"max.				
Vibration Level _____				
Fan Cylinder Height _____				
Mech.Eqpt. Support Mat'l _____				
Oil Fill and Drain Lines _____				
Oil Level Sight Glass _____				
Vibration Limit Switches _____				
Makeup Valves _____				
Other Components _____				
Motor Manufacturer _____				
Name Plate Data: hp _____ RPM _____ Phase _____ Hz _____ Volts _____				
F.L. Amps _____ Frame _____ SF _____ Special Info. _____				
Last Lubrication – Date _____ _____				
Grease Used – Type _____				
Any Unusual Noise? No Yes Action Required _____				
Any Unusual Vibration? No Yes Action Required _____				
Any Unusual Heat Build-up? No Yes Action Required _____				

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COOLING TECHNOLOGIES

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